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16. Abstract (Limit: 200 words)

This report assesses the risk of exposure to 1,1,2,2-tetrachloroethane. This study is part of a program to identify the sources of and evaluate exposure to 129 priority pollutants. The analysis is based on available information from government, industry, and technical publications assembled in March of 1981.

The assessment includes an identification of releases to the environment during production, use, or disposal of the substance. In addition, the fate of 1,1,2,2-tetrachloroethane in the environment is considered; ambient levels to which various populations of humans and aquatic life are exposed are reported. Exposure levels are estimated and available data on toxicity are presented and interpreted. Information concerning all of these topics is combined in an assessment of the risks of exposure to 1,1,2,2-tetrachloroethane for various subpopulations.

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AN EXPOSURE AND RISK ASSESSMENT FOR 1,1,2,2-TETRACHLOROETHANE

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FOREWORD

Effective regulatory action for toxic chemicals requires an understanding of the human and environmental risks associated with the manufacture, use, and disposal of the chemical. Assessment of risk requires a scientific judgment about the probability of harm to the environment resulting from known or potential environmental concentrations. The risk assessment process integrates health effects data (e.g., carcinogenicity, teratogenicity) with information on exposure. The components of exposure include an evaluation of the sources of the chemical, exposure pathways, ambient levels, and an identification of exposed populations including humans and aquatic life.

This assessment was performed as part of a program to determine the environmental risks associated with current use and disposal patterns for 65 chemicals and classes of chemicals (expanded to 129 "priority pollutants") named in the 1977 Clean Water Act. It includes an assessment of risk for humans and aquatic life and is intended to serve as a technical basis for developing the most appropriate and effective strategy for mitigating these risks.

This document is a contractors' final report. It has been extensively reviewed by the individual contractors and by the EPA at several stages of completion. Each chapter of the draft was reviewed by members of the authoring contractor's senior technical staff (e.g., toxicologists, environmental scientists) who had not previously been directly involved in the work. These individuals were selected by management to be the technical peers of the chapter authors. The chapters were comprehensively checked for uniformity in quality and content by the contractor's editorial team, which also was responsible for the production of the final report. The contractor's senior project management subsequently reviewed the final report in its entirety.

At EPA a senior staff member was responsible for guiding the contractors, reviewing the manuscripts, and soliciting comments, where appropriate, from related programs within EPA (e.g., Office of Toxic Substances, Research and Development, Air Programs, Solid and Hazardous Waste, etc.). A complete draft was summarized by the assigned EPA staff member and reviewed for technical and policy implications with the Office Director (formerly the Deputy Assistant Administrator) of Water Regulations and Standards. Subsequent revisions were included in the final report.

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Office of Water Regulations and Standards

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The Arthur D. Little, Inc., task manager for this study was Joanne Perwak. Other major contributors were Melanie Byrne (effects on aquatic biota), Muriel Goyer (human effects), Leslie Nelken (environmental fate), and Melba Wood (monitoring data). Jane Metzger and Irene Rickabaugh were responsible for report production.

The materials balance for 1,1,2,2-tetrachloroethane (Chapter 3.0) was developed by Kenneth Moss and Patricia Cruse of Acurex Corporation, under contract 68-01-6017 to the Monitoring and Data Support Division, Office of Water Regulations and Standards, U.S. EPA. Patricia Leslie was responsible for report production on behalf of Acurex Corporation.

The U.S. Environmental Protection Agency project manager was Dr. Gregory Kew.

1.0 TECHNICAL SUMMARY

The Monitoring and Data Support Division, Office of Water Regulations and Standards, U.S. Environmental Protection Agency, is conducting a program to identify the sources of, and evaluate the exposure to, 129 priority pollutants. This report assesses exposure to 1,1,2,2-tetrachloroethane in the environment and the risks associated with that exposure.

1.1 EXPOSURE AND RISK CONSIDERATIONS - HUMANS

The compound 1,1,2,2-tetrachloroethane has been shown to be carcinogenic and teratogenic in mice, as well as mutagenic in three submammalian systems. Based upon the evidence of animal carcinogenicity, EPA's Carcinogen Assessment Group designated this chemical as a suspected human carcinogen. Subsequently, EPA's Office of Water Regulations and Standards specified the ambient freshwater quality criterion for maximum protection of human health as zero µg/l. The levels in water calculated to result in incremental lifetime cancer risks of 10^{-5}, 10^{-6}, and 10^{-7}, through ingestion of both water and contaminated aquatic organisms, are 1.7 µg/l, 0.17 µg/l, and 0.017 µg/l, respectively.

Evidence of exposure is extremely limited. The compound has not been detected in drinking water surveys at a detection limit less than 1 µg/l. One report was found of groundwater contamination for a chemical disposal site, with concentrations as high as 1590 µg/l detected. Though it is not likely that this single incident represents a typical human exposure level, the potential for exposure exists, as well as the potential for detection at other waste disposal sites. However, the limited use of this chemical suggests that widespread exposure is not likely.

Inhalation exposures have been reported infrequently in the vicinity of organic chemical production facilities in the Gulf Coast area; however, exposure levels appear to be less than 2 µg/day. Levels as high as 3 $\mu g/m^3$ have been reported in the air in the immediate vicinity of a waste disposal site; this level could result in a potential exposure of 60 µg/day. Again, the frequency of detection was very low, and thus the subpopulation exposed is expected to be quite small.

Thus, at the exposures mentioned above, a few small subpopulations could potentially be exposed to levels that result in an additional lifetime cancer risk of greater than 10^{-5} based upon the dose response extrapolation for the water quality criteria. However, there is no actual evidence of exposure at these levels. Waste disposal sites appear to represent the greatest potential source of non-occupational exposure, either through consumption of contaminated groundwater, or inhalation.

1.2 EXPOSURE AND RISK CONSIDERATIONS -- OTHER BIOTA

The lowest level at which effects on aquatic organisms have been observed is 2400 µg/l. The limited monitoring data suggest that levels are generally below 10 µg/l, and no reported ambient level, even transiently, exceeded 2400 µg/l. Thus, based on the limited data available, 1,1,2,2-tetrachloroethane does not appear to present a significant risk to aquatic biota. However, a wide range of species have not been tested.

1.3 SOURCES AND FATE IN THE ENVIRONMENT

The compound 1,1,2,2-tetrachloroethane is no longer produced in the U.S. An estimated 22,000 kkg were produced in 1978 and used primarily as a chemical intermediate. A small amount of 1,1,2,2-tetrachloroethane (about 56 kkg) is now imported for use as a solvent in such industries as pharmaceuticals, leather tanning, and textiles. This chemical is produced inadvertently in the production of other chlorinated hydrocarbons, specifically vinyl chloride monomer and 1,1,1-trichloroethane.

The reported half-life of 1,1,1-trichloroethane in the troposphere has been estimated to be on the order of a few years. One might infer comparable persistence for 1,1,2,2-tetrachloroethane. It is likely that most of the released compound will reach the stratosphere, where it may be dissociated.

The primary fate pathway of 1,1,2,2-tetrachloroethane entering aquatic systems is expected to be volatilization. Hydrolysis, biodegradation, and bioaccumulation are not expected to be competitive processes. Though the half-life for volatilization in the laboratory has been found to be 56 minutes, the half-life is expected to be considerably longer in actual aquatic systems, as has been found for other structurally-related volatile organics (i.e., 1,.,1-trichloroethane and 1,2-dichloroethane).

The fate of 1,1,2,2-tetrachloroethane in soil is unknown but is expected to be dominated by volatilization and movement with groundwater.

2.0 INTRODUCTION

The Office of Water Regulations and Standards, Monitoring and Data Support Division, U.S. Environmental Protection Agency, is conducting a program to evaluate the exposure to and risks resulting from 129 priority pollutants in the nation's environment. The risks to be evaluated include potential harm to human beings and deleterious effects on fish and other biota. The goal of the task under which this report has been prepared is to integrate information on cultural and environmental flows of specific priority pollutants and estimate the risk based on receptor exposure to these substances. The results are intended to serve as a basis for developing suitable regulatory strategies for reducing the risk, if such action is indicated.

This report provides a brief summary of the production use, distribution, fate, effects, exposure, and potential risks of 1,1,2,2-tetrachloroethane. As of 1979, this compound was no longer produced in the U.S. and only rarely detected in environmental media. Hence, the available information is sparse for most aspects of the risk assessment.

The report is organized as follows:

Chapter 3 presents a materials balance for 1,1,2,2-tetrachloroethane that considers quantities of the chemical consumed in various applications, the form and amount of pollutant released to the environment, the environmental compartment initially receiving it, and, to the degree possible, the locations and timing of releases.

Chapter 4 describes the distribution of 1,1,2,2-tetrachloroethane in the environment by presenting available monitoring data for various media and by considering the physicochemical and biological fate processes that determine the distribution in the environment.

Chapter 5 describes the available data concerning the toxicity of 1,1,2,2-tetrachloroethane for humans and laboratory animals and quantifies the likely level of human exposure via major known exposure routes.

Chapter 6 considers toxicological effects on and exposure of biota, predominantly aquatic biota.

Chapter 7 presents a range of exposure conditions for humans and other biota and discusses the risk presented by various exposures to 1,1,2,2-tetrachloroethane.

3.0 MATERIALS BALANCE

3.1 INTRODUCTION

One perspective from which exposure to a chemical may be evaluated is that of a materials balance. Since the total mass of all materials entering a system equals the tocal mass of all materials leaving that system, less those materials the system accumulates or retains, a materials balance may be performed around any individual operation that ultimately places a specific population at risk (e.g., process water discharges creating surface water contamination). Each overall materials balance, therefore, consists of a collection of smaller-scale ones, each of which is composed of releases to specific environmental media.

This chapter reviews both published and unpublished data concerning the production, use, and disposal of 1,1,2,2-tetrachloroethane within the United States. Information available from the literature has been critiqued and compiled in order to present an overview of major sources of environmental releases of 1,1,2,2-tetrachloroethane. Fully annotated tables have been included.

Production, use, and disposal aspects of 1,1,2,2-tetrachloroethane are presented in Sections 3.2 through 3.4. A summary, along with a preliminary materials balance flowsheet for 1,1,2,2-tetrachloroethane, is included in Section 3.5.

3.2 PRODUCTION OF 1,1,2,2-TETRACHLOROETHANE

The solvent 1,1,2,2-tetrachloroethane is no longer produced in the U.S. This section will briefly discuss past production and present-day sources of the compound, either direct (e.g., imports) or inadvertent (e.g., manufacture of other chlorinated hydrocarbons).

3.2.1 Direct Sources

The compound 1,1,2,2-tetrachloroethane can be manufactured by direct chlorination or oxychlorination of ethylene, or by chlorination of acetylene. Hooker Chemical Co. (Taft, LA), the sole U.S. producer of 1,1,2,2-tetrachloroethane, used the acetylene process until it ceased production in March, 1978 (Miller 1980). An estimated 22,000 kkg were produced that year (Johnston 1978). Based upon an emission factor of 0.50 g/kg 1,1,2,2-tetrachloroethane produced (EPA 1977a), approximately 11 kkg were emitted to the atmosphere that year. These releases stemmed from the reflux condenser vent of the chlorination reactor. Only traces of the solvent were found in wastewater (EPA 1977a).

The profile for subsequent years is different, however. In 1979, the 88 kkg of 1,1,2,2-tetrachloroethane imported from Canadian Industries, Ltd. represented the only source of U.S. supply. In 1980, an

estimated 56 kkg were imported. There are no reported exports (Harris 1980, Miller 1980).

3.2.2 Indirect Sources

The manufacture of other chlorinated hydrocarbons, specifically vinyl chloride monomer (VCM) and 1,1,1-trichloroethane, generates small quantities of byproduct 1,1,2,2-tetrachloroethane. Most of the 1,1,2,2-tetrachloroethane so produced is recycled as feedstock for other chlorocarbons or is incinerated.

Some quantity of 1,1,2,2-tetrachloroethane is found in tars and heavy ends from VCM manufacture. Based on VCM production of 2.66 x 10^6 kkg (via 1,2-dichloroethane), 0.8 kg tar produced/kkg VCM produced and 12% 1,1,2,2-tetrachloroethane (by weight) in tar, 255 kkg of 1,1,2,2-tetrachloroethane would be contained in VCM tar (Jensen et al. 1975, USITC 1980). Tars are usually treated to recover the organic compounds present and then are either landfilled or incinerated (McPherson et al. 1979). If the organic compound recovery process is 90% efficient, 26 kkg of 1,1,2,2-tetrachloroethane would be available for land disposal or incineration. Although landfilling of these tars has, in the past, been the usual disposal method, incineration of VCM tars is becoming more common as regulations governing landfills are increased. For purposes of this materials balance, it has been assumed that 50% of the tars are landfilled and 50% are incinerated (incineration efficiency = 99.5%). Thus 13 kkg of 1,1,2,2-tetrachloroethane are land disposed, while <1 kkg is emitted to the atmosphere via incineration.

VCM heavy ends reportedly contain 0.004 kkg of 1,1,2,2-tetrachloroethane per kkg VCM produced (Gruber 1976). Thus if 2.89 x 10^6 kkg of VCM were produced in 1979 (USITC 1980), 11,560 kkg of 1,1,2,2-tetrachloroethane would be generated per year. These wastes are either recycled or incinerated, both at 99.5% efficiency (Kew 1980). Therefore, approximately 60 kkg of 1,1,2,2-tetrachloroethane would be emitted to the atmosphere from recycle distillation vents or incineration per year. The major wastewater source of 1,1,2,2-tetrachloroethane is the recycle purification of the intermediate, 1,2-dichloroethane. A typical total organic carbon (TOC) discharge rate is 0.15 kg TOC/454 kg VCM product (EPA 1977a). If 1,1,2,2-tetrachloroethane is assumed to be present in the recycle effluent stream at the same proportion of TOC as in the heavy ends (i.e., 0.004 kkg/kkg), a total of 3.8 kkg 1,1,2,2-tetrachloroethane would be discharged to water from the manufacture of 2.89 x 10^6 kkg of VCM (see Figure 3-1).

The compound 1,1,2,2-tetrachloroethane is also found in solid wastes from 1,1,1-trichloroethane manufacture via vinyl chloride. Based on SRI estimates of 40.8 kg 1,1,2,2-tetrachloroethane produced per kkg of 1,1,1-trichloroethane (via vinyl chloride) and a 1979 production of 297,000 kkg of 1,1,1-trichloroethane, about 12,100 kkg of 1,1,2,2-tetrachloroethane were generated in 1979 (Elkin 1969). These solid wastes are currently recycled (99.5% efficiency assumed) as a feedstock for other chlorinated hydrocarbons, such as vinylidene chloride and

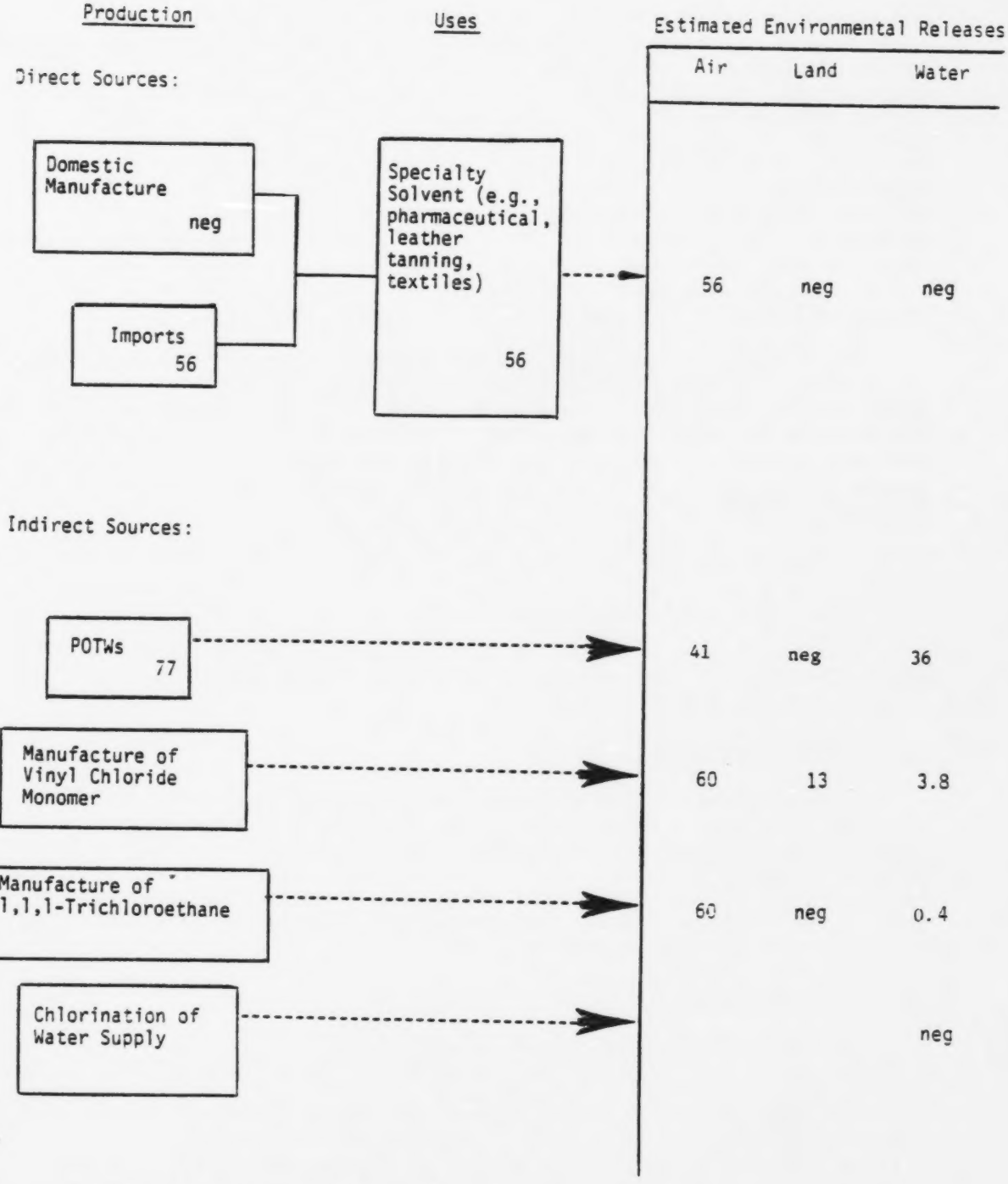

Figure 3-1. U.S. 1,1,2,2-Tetrachloroethane Materials Balance, 1980 (kkg)

trichloroethylene (EPA 1979d). Thus, about 60 kkg of 1,1,2,2-tetrachloroethane were emitted to the atmosphere in 1979 from 1,1,1-trichloroethane manufacture. An estimate of the loading to water of 1,1,2,2-tetrachloroethane from this manufacturing process can be derived using the method followed for VCM manufacture (see above). If it is assumed that 40.8 kg/kkg is also the concentration of 1,1,2,2-tetrachloroethane in the TOC of the recycle effluent stream, and that the concentration of TOC is again 0.15 kg/434 kg, a total of 0.4 kkg 1,1,2,2-tetrachloroethane will be released to water during the manufacture of 297,000 kkg 1,1,1-trichloroethane (see Figure 3-1). Previously, these solid wastes were disposed of on land. Due to rising costs of chlorine, paucity of appropriate disposal sites, and RCRA regulations, recycle/reuse of these wastes is presently more economically attractive.

Chlorination of water supplies and wastewaters is a possible pathway for formation of various chlorinated hydrocarbons; however, there is no clear evidence that this process is a source of 1,1,2,2-tetrachloroethane. The EPA National Organics Monitoring Survey (EPA 1977b) detected the compound, but did not quantify it; the National Organics Reconnaissance Survey (Symons et al. 1975) did not address 1,1,2,2-tetrachloroethane. While this chemical was detected in some POTW* effluents and sludges (see Table 3-1), there is no indication of an increase in concentration upon treatment. If anything there may be a net removal of this compound.

3.3 USES OF 1,1,2,2-TETRACHLOROETHANE

The following is a discussion of the possible uses of 1,1,2,2-tetrachloroethane. Included are estimates of environmental releases from present and past practices.

3.3.1 Manufacturing Intermediate

The major domestic use of 1,1,2,2-tetrachloroethane, until cessation of production, was as a feedstock in the manufacture of trichloroethylene, tetrachloroethylene and 1,2-dichloroethylene (Archer 1979). Today, however, domestic production of 1,1,2,2-tetrachloroethane has been terminated due to the high cost of acetylene. Environmental releases from the manufacture of other chlorinated hydrocarbons have been discussed as inadvertent sources in Section 3.2.2.

3.3.2 Solvent Uses

The major market today for the 56 kkg of 1,1,2,2-tetrachloroethane imported to the U.S. is as a specialty process and cleaning solvent in various industries; the primary use is as an extraction solvent in the pharmaceutical industry (Aldrich 1980). Judging from (1) the low incidence of detection in industrial wastewaters (see Table 3-2); (2) the detection of only trace amounts in treated wastewater of certain exemplary industries (EPA 1979a,b; EPA 1980d,e,f); (3) the use of exhaust systems in leather tanning to vent 99% of solvent fumes to the atmosphere (Lollar 1980); (4) the assumption that pharmaceutical extraction

* POTW = Publicly-Owned Treatment Works

Table 3-1. 1,1,2,2-Tetrachloroethane Distribution in POTWs and Sludge, Selected Urban Sites

Plant	Average Flow (10^6 l/day)	% Industrial Contribution	Concentrations (µg/l) Influent	Effluent	Sludge
1	340	30	ND	ND	ND
2	30	<5	ND	ND	ND
3	42	10	ND	ND	ND
4	320	7	18	2	43
5	83	10	1	<1	40
6	27	38	<1	<1	0.5
7	190	15	<5	<5	26
8	87	10	<1	<1	<5
9	200	10	1	<5	<3
10	87	5	ND	ND	ND
11	160	18	ND	ND	ND
12	150	50	<1	<1	0.5
13	64	33	ND	ND	ND
14	53	25	ND	ND	ND
15	27	25	ND	ND	ND
16	550	16	<10	ND	ND
17	57	25	<1	<1	32
18	240	50	<1	<1	41
19	260	20	<1	<1	15
20	450	15-22	ND	ND	ND
Median Values			<1	<0.5	0.25
Simple Mean			2.1	1.0	10.0
Flow Weighted Mean			3.9	1.0	

[a] Not Detected

[b] For calculation of means and medians, values preceded by < are taken as that number (upper limit) and ND as zero.

Source: EPA (1980).

Table 3-2. Frequency of 1,1,2,2-Tetrachloroethane Detection in Industrial Wastewater

Industry	Frequency # found/# samples	Percent
Leather Tanning	2/81	2.5%
Gum and Wood Products	1/18	5.6
Printing and Publishing	3/109	2.8
Paint and Ink	2/94	2.1
Pesticides	7/147	4.8
Pharmaceuticals	5/212	2.4
Organics and Plastics	25/723	3.5
Coal Mining	29/249	11.7
Petroleum Refining	11/76	14.5
Iron and Steel	4/431	0.9
Nonferrous Metals	12/173	6.9
Photographic	1/25	4.0
Inorganic Chemicals	2/107	1.9
Auto and Other Laundries	2/56	3.6
Phosphates (Fertilizer Manufacture)	6/33	18.2
Mechanical Products	1/35	2.9

Source: EPA (1980b).

solvents that are recycled from vent condensers and carbon recovery systems (Lo 1980) will eventually be completely volatilized; and (5) the fact that negligible amounts of 1,1,2,2-tetrachloroethane accumulate in POTW sludge (see Section 3.4), it is estimated that all of the 1,1,2,2-tetrachloroethane used in solvent applications is released to the atmosphere (see Figure 3-1). This emission will be divided among a number of different operations and facilities, and thus the release will be widely dispersed.

Despite the fact that 1,1,2,2-tetrachloroethane is no longer produced, poorly controlled storage and disposal of chemical production wastes in the past can result in releases. The Ott/Story Chemical Company site (now owned by Cordova Chemical Company) in North Muskegon, Michigan is presently being investigated for groundwater contamination. Levels of 1,1,2,2-tetrachloroethane in the range <5-1,590 µg/l have been detected, along with other organic pollutants. It is presumed that the source of 1,1,2,2-tetrachloroethane contamination was its use as a process solvent, cleaning solvent, or manufacturing intermediate in the late 1950s and early 1960s (Cardy 1980, Shuckrow et al. 1980). The presence of other chlorinated solvents in groundwater has been documented (e.g., Phillipe 1980, Fishburn 1980), but these studies do not include information on 1,1,2,2-tetrachloroethane, either because it was not detected or not included in the chemical analysis.

3.4 1,1,2,2-TETRACHLOROETHANE IN PUBLICLY OWNED TREATMENT WORKS (POTWs)

Input of 1,1,2,2-tetrachloroethane to POTWs is largely dependent upon variations in industrial discharges feeding the POTWs and the types of industry in a particular municipality. A recent EPA study of selected urban POTW facilities with secondary treatment and varying feed conditions produced a materials balance of 1,1,2,2-tetrachloroethane shown in Table 3-2.

An overall materials balance can be constructed using a total POTW flow of 10^{11} l/day (EPA 1978) and simple mean values of 2.1 µg/l (influent) and 1.0 µg/l (effluent) for 1,1,2,2-tetrachloroethane (see Table 3-2). It is assumed for purposes of these calculations that influent and effluent flow rates are equal, i.e., that water losses from sludge removal and evaporation are small compared with influent flows. Using these assumptions, 36 kkg 1,1,2,2-tetrachloroethane were discharged from POTWs in 1980, while there was an input of 77 kkg (see Figure 3-1).

The amount of 1,1,2,2-tetrachloroethane discharged in sludge can be estimated from the concentration in sludge and quantity of dry sludge produced annually, 6.0×10^6 kkg (EPA 1979c). If the simple mean concentration of 1,1,2,2-tetrachloroethane in POTW wet sludge is assumed to be 10 µg/l (see Table 3-2) and wet sludge is assumed to be 95% water by weight, a negligible amount (approximately 1.2 kg) of 1,1,2,2-tetrachloroethane is discharged in sludge.

The quantity of 1,1,2,2-tetrachloroethane released to the atmosphere may be estimated by difference from the above calculations (influent loading-effluent and sludge loading), given the following assumptions: (1) the solvent recycled within the activated sludge process will eventually be emitted; (2) the solvent biologically degraded is negligible; and (3) 1,1,2,2-tetrachloroethane is lost to the atmosphere by mechanical stripping, or aeration. Thus, an estimated 41 kkg of 1,1,2,2-tetrachloroethane is released to the atmosphere from POTWs.

How well existing data represent the actual situation in POTWs nationwide is still open to some question. Although one study that serves as an information source for this section and Table 3-2 (EPA 1980b) reported 1,1,2,2-tetrachloroethane in POTW influent, a second report (EPA 1980a) did not find the solvent in 40 POTW samples. It can be noted from the data in Table 3-1 that most of the values are at or below detection limits, with only three positive data points. Furthermore, different totals for influent (37 kkg), effluent (18 kkg) and atmospheric emissions (19 kkg) of 1,1,2,2-tetrachloroethane result if median values are used in the calculations instead of simple mean values. In light of these factors, the total amount of 1,1,2,2-tetrachloroethane in POTWs could be considerably lower than that estimated above.

3.5 SUMMARY AND CONCLUSIONS

Existing information on 1,1,2,2-tetrachloroethane releases to the environment from production, use and disposal is presented in tabular format in Figure 3-1. It is apparent that the only direct use of the compound, as a specialty solvent, mostly results in atmospheric emissions due to the nature of the operations involved (see Section 3.3.2). This use is spread over a number of operations and facilities, so that environmental releases are likely to be widely dispersed.

The only other major sources of 1,1,2,2-tetrachloroethane in the environment are indirect: in tars and "heavy ends" from vinyl chloride monomer production, in residues from 1,1,1-trichloroethane manufacture, as air emissions from recycle of by-products or reactants in manufacture of both vinyl chloride monomer and 1,1,1-trichloroethane, and from POTWs. Improper management of waste disposal and storage can also result in air emissions and groundwater contamination, although relatively small amounts of 1,1,2,2-tetrachlorethane are involved (see Section 3.3.2).

REFERENCES

Aldrich Chemical Co. Personal Communication, December, 1980.

Archer, W. Other chloroethanes (In) Kirk-Othmer Encyclopedia of Chemical Technology; 5:735-736;1979.

Cardy, D. (Cordova Chemical Co.) Personal Communication, November, 1980.

Elkin, L.M. Chlorinated Solvents. Report No. 48, Stanford Research Institute, Menlo Park, Calif. 1969.

Environmental Protection Agency, 1975. Engineering and Cost Study of Air Pollution Control for the Petrochemical Industry, vol. 8: vinyl chloride manufacture by the balanced process. Washington, DC: EPA 450/3-73-0061;1975.

Environmental Protection Agency, 1977a. Industrial Process Profiles for Environmental Use: chapter 6, The industrial organic chemical industry. Cincinnati, OH: EPA 600/2-77-023f;1977.

Environmental Protection Agency, 1977b. National Organic Monitoring Survey. Washington, DC: Office of Water Supply; 1977.

Environmental Protection Agency, 1978. Needs Survey. Washington, DC: Office of Water Planning and Standards; 1978.

Environmental Protection Agency, 1979a. Development Document for Effluent Limitations Guidelines and Standards: Leather Tanning and Finishing Point Source Category. Washington, DC: EPA 440/1-79-016; 1979.

Environmental Protection Agency, 1979b. Development Document for Effluent Limitations Guidelines and Standards for the Textile Mills Point Source Category. Washington, DC: EPA 440/1-79-022b;1979.

Environmental Protection Agency, 1979c. Comprehensive Sludge Study Relevant to Section 8002(g) of R.C.R.A. of 1976. Washington, DC: EPA SW-802; October, 1979.

Environmental Protection Agency, 1979d. Emissions Control Options for the Synthetic Organic Chemicals Manufacturing Industry. Washington, DC: EPA Contract 68-02-2577;1979.

Environmental Protection Agency, 1980a. Priority Pollutant Frequency Listing, Tabulations and Descriptive Statistics. Memo from D. Neptune, Analytical Programs to R.B. Schaffer, Director of Effluent Guidelines Division. Washington, DC: January, 1980.

Environmental Protection Agency, 1980b. Fate of Priority Pollutants in Publicly Owned Treatment Works, Interim Report. Washington, DC: EPA 440/1-80/301;1980.

Environmental Protection Agency, 1980c. Chlorinated hydrocarbon manufacture: an overview. Washington, DC: EPA Contract 68-02-2567; 1980.

Environmental Protection Agency, 1980d. Contractor's Engineering Report for the Development of Effluent Limitations Guidelines and Standards for the Pharmaceutical Manufacturing Point Source Category. Washington, DC: EPA 440/1-80/084a;1980.

Environmental Protection Agency, 1980e. Treatability Manual, Vol. I, Treatability Data. Washington, DC: EPA 600/8-80-042a;1980.

Environmental Protection Agency, 1980f. Environmental Assessment Data System. Research Triangle Park, NC: National Computing Center; November, 1980.

Fishburn, Maj. G. (Occupational and Environmental Health Lab., Brooks Air Force Base, Texas.) Personal Communication. June, 1980.

Gruber, G.I. 1976. Assessment of Industrial Hazardous Waste Practices, Organic Chemicals, Pesticides and Explosives Industries. Rep. No. 25666-6010-TU-00. TRW, Redondo Beach, Calif.

Harris, M. (Dept of Commerce) Personal Communication. December, 1980.

Jensen, S.; Lange, R.; Parlmert, K.; Renberg, L.; On the chemistry of EDC-tar and its biological significance in the sea. Proceedings of the Royal Society of London, Series B. 189:333-346;1975.

Johnson, T.R. (Hooker Chemical Co. Taft, LA.) Personal Cummunication. December 15, 1978. From: Versar, 1979: Production and Use of 1,1,2,2-Tetrachloroethane.

Kew, G. U.S. EPA Personal Communication. November, 1980.

Lo, Teh (Hoffman-LaRoche, Inc.) Personal Communication. May 1980.

Lollar, R. (University of Cincinnati, Tanning Research Dept.) Personal Communication. September, 1980.

McPherson, R.W.; Starks, C.M.; Fryar, G.J., Vinyl chloride monomer... what you should know. Hydrocarbon Process. 3:75-88;1979.

Miller, M. (Hooker Chemical Co. Taft, LA.) Personal Communication, November, 1980.

Phillipe, S. (Water Quality Board of California) Personal Communication. June, 1980.

Shuckrow, A.J.; Pajak, A.J.; Osheka, J.W.; James, S.C.. Bench scale assessment of technologies for contaminated ground water treatment (In) Management of Uncontrolled Hazardous Waste Sites, EPA National Conference, October, 1980. Hazardous Materials Control Research Institute, Silver Spring, MD.

Symons, J.M.; Bellar, T.A.; Caldwell, J.K.; K ropp, K.L.; Robeck, D.R., Slocum, C.J.; Smith, B.L.; Stevens, A.A. National organics reconnaissance survey for halogenated organics. Journal of America Water Works Association, November 1975.

U.S. International Trade Commission. Synthetic organic chemicals, U.S. production and sales, 1979. Washington, DC: U.S. Government Printing Office;1980.

4.0 FATE AND DISTRIBUTION IN THE ENVIRONMENT

4.1 INTRODUCTION

This chapter summarizes the current state of knowledge concerning the fate and distribution of 1,1,2,2-tetrachloroethane in the environment. First, monitoring data are presented from STORET and a limited number of surveys of the concentrations of the compound in ambient and effluent waters, wastewater from POTWs, and the atmosphere. Next the environmental fate and chemistry of 1,1,2,2-tetrachloroethane are considered in order to elucidate the chemical and physical processes that determine its ultimate fate in environmental media and, therefore, the opportunities for exposure of humans and other biota.

4.2 MONITORING DATA

The STORET Water Quality Control Information System serves as the primary source of monitoring data for 1,1,2,2-tetrachloroethane in the aqueous environment. Although limited, a survey of national and regional distributions of 1,1,2,2-tetrachloroethane is presented herein.

STORET data are discussed first to exhibit the overall distribution of the pollutant in ambient and effluent waters, well waters, sediment, and fish tissue. The remaining discussion presents results documented in published literature from sampling of 1,1,2,2-tetrachloroethane in various types of water and in the atmosphere.

4.2.1 STORET

Only 440 analyses for 1,1,2,2-tetrachloroethane in ambient waters are recorded in STORET (see Table 4-1) along with 450 effluent analyses. Roughly 90% of these reports indicate that if 1,1,2,2-tetrachloroethane were present at all, it was at levels below the detection limit of the analytical method used. (Detection limits most commonly cited in conjunction with these analyses were 5 µg/l and 10 µg/l.) Sixteen of the 40 "unremarked" (above detection limit) ambient water observations indicated levels less than or equal to 1 µg/l. The remaining 24 unremarked observations indicated levels above 1.7 µg/l. (The significance of 1.7 µg/l is discussed in Section 5.1.1.) However, 13 of the remaining 24 clearly are associated with a single large pesticide manufacturing facility, which remains under close scrutiny of the state and the EPA regional office. (The most recent observations indicate a 200-fold decrease over earlier concentrations to around 5 µg/l.) When the complete STORET entry is examined for the remaining nine observations in ambient waters, four are found to be associated with other specific industries, while three values less than 2 µg/l are reported for the lower Hudson River without reference to a particular industry. The final two observations are reported for the Ohio River bordering West Virginia, again without reference to particular industries.

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TABLE 4-1. PERCENTAGE DISTRIBUTION OF UNREMARKED AND REMARKED AMBIENT CONCENTRATIONS OF 1,1,2,2-TETRACHLOROETHANE IN STORET, 1980

Major River Basin	Unremarked data[a] (% at conc.)						Remarked data[a] (% at conc.)					
	No. Observations	≤1	1.1-10	10.1-100	100.1-1000	>1000 µg/l	No. Observations	≤1	1.1-10	10.1-100	100.1-1000	>1000 µg/l
Northeast	11	73%	27				6	83		17		
North Atlantic							107	7	93			
Southeast							28		100			
Tennessee River	2		50	50			52	52	48			
Ohio River	3	33	33	33			2	100				
Lake Erie	3	100					13		38	62		
Upper Mississippi	5		40	20	40		56	5	64	30		
Missouri River	13		31	54		15	14	29	21	50		
Lower Mississippi							4		100			
Colorado River							15	100				
Western Gulf							88	17	83			
Pacific Northwest	1	100					13	38	62			
California	2	100					1		100			
Great Basin							1	100				
Puerto Rico												
UNITED STATES	40	38	28	25	5	5	400	21	71	8		

[a]Remarked data indicates that the compound was not detected at the level reported. Unremarked data are positive values.

Source: U.S. EPA STORET (November 12, 1980).

The highest effluent concentration of 58,600 µg/l reported in STORET was recorded in New York City (Cambridge Cleaners, Manhattan) in December 1977. However, another sample from that location on the same day was recorded at 0.01 µg/l, suggesting that the high value may have represented a transient release or an analytic error.

The compound 1,1,2,2-tetrachloroethane was not detected in well waters monitored in several southern states, according to the STORET data base. In addition, tetrachloroethane was not detected in sediment or fish tissue samples at 117 various sites in New Jersey, and some southern and western states.

4.2.2 Other Surveys

4.2.2.1 Wastewater

Young (1978) examined municipal wastewaters from the four largest POTWs in Southern California for priority pollutants. Samples taken in the summer of 1978 did not contain quantifiable levels of 1,1,2,2-tetrachloroethane at any treatment stage (primary, secondary, or final), using a method with a detection limit of 10 µg/l.

4.2.2.2 Atmosphere

Samples of ambient air have been collected in various regions of the United States over several years, both in the vicinity of industrial sources and in non-industrial areas. Singh et al. (1980) reported average levels of 40-82 ng/m^3 after sampling atmospheric levels in Houston, TX, St. Louis, MO, Denver, CO, and Riverside, CA. The New Jersey Department of Environmental Protection (1980) reported the results of a survey in that state of 263 samples; trace quantities of 1,1,2,2-tetrachloroethane were found in 13, and quantifiable levels in seven samples. The maximum reported concentration was about 29,000 ng/m^3

Table 4-2 exhibits the estimated levels of 1,1,2,2-tetrachloroethane from ambient air samples taken during sampling cycles at various locations as reported by Pellizzari (1978). Only 13 out of 201 ambient air samples collected in 24 locations contained detectable concentrations. It is evident that 1,1,2,2-tetrachloroethane is not often detected in the atmosphere, although monitoring data are scarce.

The highest levels were found in the vicinity of the Kin-Buc disposal site in New Jersey. However, samples taken at other times showed undetectable levels at the same locations, a finding suggesting that the higher levels were infrequent.

4.2.2.3 Groundwater

Results of a groundwater survey in New Jersey indicated that 1,1,2,2-tetrachloroethane was found in 2.1% of 1118 samples, using analytical methods with a detection limit of 0.3 µg/l, and that the maximum concentration found was 2.7 µg/l, although the average and median values were

TABLE 4-2. LEVELS OF 1,1,2,2-TETRACHLOROETHANE DETECTED IN AMBIENT AIR OF SEVERAL U.S. REGIONS

Location	Detection Limits (ng/m^3)	Detection Frequency	Levels Found (ng/m^3)
Kin-Buc Disposal Site, Edison, NJ	20-54	3/29	1389; 15,000; 22,285
Cities in Northern NJ	20-50	1/6	2872
Tulsa, OK	6-42	0/7	
Houston, TX area	6-105	2/32	19, 33
Kanawha Valley, WV	<6-31	0/29	
Front Royal, VA	6-40	0/28	
South Charleston, WV	6-139	0/6	
Birmingham, AL	6-113	0/6	
Baton Rouge, LA area	6-58	2/23	trace, 71
Upland, CA	6-62	0/10	
Magna, UT	6-46	0/6	
Grand Canyon, AZ	6-156	0/8	
Iberville Parish, LA (near industrial complex)		5/11	52-1573

Source: Pellizzari (1978).

were much lower. A more precise breakdown of the number of positive results in various concentration ranges is not yet available (R. Tucker, N.J. Department of Environmental Protection, Personal Communication 1981).

Similarly, Kim and Stone (1979) reported that 1,1,2,2-tetrachloroethane was detected in only one of 47 samples from 39 wells in New York (excluding Long Island).

Thus, limited evidence suggests that 1,1,2,2-tetrachloroethane is not commonly found in groundwater.

4.3 ENVIRONMENTAL FATE AND CHEMISTRY

The compound 1,1,2,2-tetrachloroethane was manufactured by one producer until 1978, for use in special solvent applications. The majority of emissions were to the air (see Chapter 3.0). Since 1978, the sources of 1,1,2,2-tetrachloroethane to the environment are a result of its use as a solvent, and its occurrence as a byproduct in the production of vinyl chloride monomer and 1,1,1-trichloroethane. Releases from these inadvertent sources are believed to be relatively small.

Some basic chemical property data for 1,1,2,2-tetrachloroethane are summarized below:

Alternate Name:	Acetylene Tetrachloride
Molecular Weight:	167.8
Molecular Formula:	$Cl_2CHCHCl_2$
Melting Point:	-36°C
Boiling Point:	146.2°C
Solubility in Water:	2900 mg/l
Vapor Pressure at 25°C	6.3 mm Hg
Log octanol/water partition coefficient	2.56

Source: Weast (1972), Versar, Inc. (1979b).

Volatilization is probably the predominant loss mechanism from water. Dilling et al. (1975) found that 1 mg/l of 1,1,2,2-tetrachloroethane has a half-life of 56 minutes in a well-stirred open container. Dilling et al. (1975) also found that the experimental half-life for hydrolysis of 1,1,1-trichloroethane was about 6 months. Thus, it is likely that hydrolysis would occur considerably more slowly than volatilization.

The affinity of 1,1,2,2-tetrachloroethane for the sediments is unknown, but the log octanol/water partition coefficient of 2.56 suggests that it may be low. In addition, Versar, Inc. (1979b) concludes that it is low, based on the low affinity of 1,1,1-trichloroethane for sediment adsorption. In addition, the bioaccumulation of this compound would probably not be an important fate mechanism due to its low BCF (bioconcentration factor) of 5 (U.S. EPA 1980). Biodegradation also

appears to be slow relative to volatilization. Tabak et al. (1980) found up to 29% degradation of 5 mg/l after one week in an acclimated microbial population.

The compound 1,1,1-trichloroethane has a reported half-life due to photo-oxidation with hydroxyl radicals of a few years in the troposphere. One might infer comparable persistence for 1,1,2,2-tetrachloroethane. Most of the released 1,1,2,2-tetrachloroethane will probably reach the stratosphere, where it can be dissociated, as is expected to occur with 1,1,1-trichloroethane (McConnell and Schiff 1978).

REFERENCES

Coleman, W.E.; Melton, R.G.; Saiter, R.W.; Kopfler, F.C.; Voto, S.J.; Allen, W.K.; Aurand, T.A. Determination of organic contamination by the grob closed-loop-stripping technique. Cincinnati, OH: Office of Research and Development, U.S. Environmental Protection Agency; 1980.

Hanst, P.L. Noxious trace gases in the air, Part II: halogenated pollutants. Chemistry 51(2):6-12; 1978.

Lillian, D.; Singh, H.B.; Appelby, A.; Lobban, L.; Arnts, R.; Gumpert, R.; Hagne, R.; Toomey, J.; Kazazis, J.; Antell, M.; Hansen, D.; Scott, B. Atmospheric fates of halogenated compounds. Environ. Sci. Technol. 9(12): 1042-1048; 1975.

McConnell, J.C.; Schiff, H.I. Methyl chloroform: Impact on stratospheric ozone. Science 199:174-177; 1978.

New Jersey Department of Environmental Protection. Second report on the findings of the state monitoring program for volatile organic substances in ambient air in New Jersey; 1980.

Pellizzari, E.D. Quantification of chlorinated hydrocarbons in previously collected air samples. Research Triangle Institute, NC: U.S. Environmental Protection Agency; 1978.

Singh, H.B.; Salas, L.J.; Smith, A.; Stiles, R.; Shigeishi, H. Atmospheric measurements of selected hazardous organic chemicals. Draft Second Year Interim Report. Grant 805990. Research Triangle Park, NC: Environmental Sciences Research Laboratory, U.S. Environmental Protection Agency; 1980.

U.S. Environmental Protection (U.S. EPA). STORET. Washington, DC: Monitoring and Data Support Division, Office of Water Regulations and Standards; 1980.

U.S. Environmental Protection Agency (U.S. EPA). Ambient water quality criteria document for chlorinated ethanes. Report No. EPA-440/5-80-029. Washington, DC: Office of Water Regulations and Standards, U.S. Environmental Protection Agency; 1980b.

Weast, J., ed. Handbook of chemistry and physics. 53rd ed. Cleveland, OH: Chemical Rubber Company; 1972.

Versar, Inc. Non-aquatic fate of 1,1,2,2-tetrachloroethane. Washington, DC: U.S. Environmental Protection Agency; 1979.

Versar, Inc. 1,1,2,2-tetrachloroethanes: statement of probable fate. Callahan, M.A.; Slimak, M.W.; Gabel, N.W.; May, I.P.; Fowler, C.F.; Freed, J.R.; Jennings, P.; Durfee, R.L.; Whitmore, F.C.; Maestri, B.; Mabey, W.R.; Holt, B.R.; Gould, C. Water-related environmental fate of 129 priority pollutants. I. Report No. EPA-440/4-79-029a. Washington, DC: Monitoring and Data Support Division, U.S. Environmental Protection Agency; 1979b.

Young, D.R. Priority pollutants in municipal wastewaters. Annual Report Southern California Coastal Waters Research Project; 1978. pp. 103-112.

5.0 EFFECTS AND EXPOSURE--HUMANS

5.1 HUMAN TOXICITY

5.1.1 Summary: Ambient Water Quality Criterion

The U.S. Environmental Protection Agency (1980) has established an ambient water criterion of zero for the maximum protection of human health from potential carcinogenic effects of exposure to 1,1,2,2-tetrachloroethane through ingestion of water and aquatic organisms. The water quality criterion is based on the results of a study demonstrating induction of hepatocellular carcinoma in male B6C3F1 mice. A concentration of not more than 1.7 µg/l of 1,1,2,2-tetrachloroethane in water is calculated (via a linearized multistage model) to keep any additional lifetime cancer risk below 10^{-5}.

Insufficient data were available to derive a water criterion for the protection of human health from other toxic effects of 1,1,2,2-tetrachloroethane.

5.1.2 Animal Studies

- 1,1,2,2-Tetrachloroethane is a liver carcinogen in both sexes of B6C3F1 mice given doses of 142 and 284 mg/kg/day five days per week by gavage for 78 weeks (i.e., 101 and 203 mg/kg/day).

Orally administered 1,1,2,2-tetrachloroethane was found to be a liver carcinogen in B6C3F1 mice of both sexes (National Cancer Institute 1978). Time-weighted average doses of 101 mg/kg/day or 203 mg/kg/day by gavage for 78 weeks, followed by a 12-week observation period, resulted in a highly significant increase in the incidence of hepatocellular carcinoma: 90%, 26%, and 6% for high, low dose, and vehicle control males, respectively, and 91%, 63%, and 0% for high, low dose, and vehicle control females, respectively.

A similar study conducted with Osborne-Mendel rats did not result in a statistically significant increase in the incidence of tumors in any of the treatment groups (National Cancer Institute 1978). Rats were given 1,1,2,2-tetrachloroethane by gavage five days per week for 78 weeks at time-weighted average doses of 62 or 108 mg/kg for males and 43 or 76 mg/kg for females. Poor survival necessitated a change in dosing regimen at week 33. From this time to completion of the study, dosages were cyclically administered with a pattern of one dose-free week followed by four weeks (5 days/week) of treatment of the level indicated. Two hepatocellular carcinomas and one neoplastic liver nodule (rare tumors in male Osborne-Mendel rats) were noted in high-dose males. Historically, this strain of rat has shown a lack of sensitivity to induction of hepatocellular carcinomas by oral administration of chlorinated organic compounds.

- 1,1,2,2-Tetrachloroethane is mutagenic in two bacterial systems and in a yeast.

Positive, dose-related mutagenic effects have been reported for Salmonella typhimurium strains TA 1530 and TA 1535, but not TA 1538, exposed to 1,1,2,2-tetrachloroethane; i.e., it induces mutations of the base substitution type only (Brem et al. 1974). Positive findings have also been observed in DNA-polymerase-deficient Escherichia coli (pol A^+/pol A^-) and for the yeast, Saccharomyces cerevisiae (Rosenkrantz 1977, Brem et al. 1974).

- 1,1,2,2-Tetrachloroethane is embryotoxic and teratogenic in mice exposed to 300-400 mg/kg/day during organogenesis.

Administration of 300-400 mg/kg/day of 1,1,2,2-tetrachloroethane during organogenesis produced embryotoxic effects and some malformations (exencephaly, cleft palate, anophthalmia) in DBA and AB-Jena strain mice. Effects were related to dose and period of treatment (Schmidt 1976).

- Subchronic exposure to 1,1,2,2-tetrachloroethane produces liver and/or kidney pathology in several species of animals. The lowest reported effect level for liver degeneration is 100 mg/m^3 in air, 4 hours per day for 11 months for rabbits.

Rats exposed to 1.94 ppm (13.3 mg/m^3) of 1,1,2,2-tetrachloroethane in air, 4 hours per day for up to 265 days had fatty livers, an increased number of white blood cells and elevated pituitary adrenocorticotropic hormone levels (Deguchi 1972). Rabbits inhaling 14.6 ppm (100 mg/m^3), 4 hours per day for 11 months exhibited liver and kidney degeneration (Navrotskig et al. 1971) while marked vacuolation of the liver was seen in monkeys inhaling 1000 ppm (6870 mg/m^3) 1,1,2,2-tetrachloroethane, 2 hours per day for 190 days (Horiguchi et al. 1962).

5.1.3 Human Data

Exposure to 1,1,2,2-tetrachloroethane is capable of producing adverse local and systemic effects in man. A single deep inhalation of ^{38}Cl-labelled 1,1,2,2-tetrachloroethane vapor resulted in the retention of 94-97% of the inhaled dose (Morgan et al. 1970, 1972), suggesting extensive absorption of this compound by man. Numerous fatalities have been recorded subsequent to its ingestion, inhalation, or cutaneous absorption (IARC 1979).

Regardless of the route of exposure, 1,1,2,2-tetrachloroethane is predominantly a central nervous system depressant and a liver and/or kidney toxicant. Other effects associated with human exposure to 1,1,2,2-tetrachloroethane include damage to blood-forming systems, pulmonary irritation, and edema and dermatologic effects (Parker et al. 1979, Hamilton and Hardie 1974, Browning 1953). The lowest reported human lethal doses by ingestion and inhalation are 50 mg/kg and 1000 mg/m^3/30 min., respectively (RTECS 1978).

5.2 HUMAN EXPOSURE

5.2.1 Introduction

As is evident from Chapters 3.0 and 4.0, very little information is available regarding the presence of 1,1,2,2-tetrachloroethane in environmental media. Consequently it is difficult to estimate human exposure. The fact that this chemical is no longer produced suggests that exposure will not be widespread.

5.2.2 Ingestion

5.2.2.1 Drinking Water

The compound 1,1,2,2-tetrachloroethane has been rarely detected in drinking water. The NOMS survey (U.S. EPA 1978) detected this chemical in some cases, but did not quantify it. The monitoring data discussed in Chapter 4.0 indicate that levels in surface water are generally less than the detection limit.

A very few cases of groundwater contamination have been reported. Chapter 3.0 described a case with levels up to 1600 µg/l in groundwater, presumably resulting from past disposal practices. In addition, Kim and Stone (1979), in a characterization of the organic chemical water quality problems in New York State, reported sampling of groundwater supplies for 112 organic chemical contaminants, including 1,1,2,2-tetrachloroethane. A total of 47 samples were collected from 39 wells outside Long Island. The chemical 1,1,2,2-tetrachloroethane was detected in one sample from Putnam County, in which the total organic content was reported to be 290 µg/l. Other contaminants found in this sample included phthalate esters, benzene, toluene, tetrachloroethylene, and trichloroethylene. Thus, it is likely that 1,1,2,2-tetrachloroethane was present at relatively low levels.

In addition, as reported in Section 4.2.2.3, 1,1,2,2-tetrachloroethane was found in 2.1% of 1118 samples taken in New Jersey, with a maximum of 2.7 µg/l. Thus it appears that this compound is rarely detected in drinking water supplies.

5.2.2.2 Food

No information is available regarding the possible contamination of food with 1,1,2,2-tetrachloroethane. However, considering the low bioaccumulation factor, the lack of detection of this compound in fish, and extremely low levels in other environmental media, food is not expected to be a significant source of human exposure.

5.2.3 Inhalation

Very sparse monitoring data are available for levels of 1,1,2,2-tetrachloroethane in air. Chapter 4.0 describes various locations that were sampled. Measurable exposure may be occurring in the vicinity of the Kin-Buc disposal site in New Jersey where 1,1,2,2-tetrachloroethane was found in air at levels up to 22 $\mu g/m^3$. However, this level was reported for the landfill site itself; the maximum level of actual population exposure in the vicinity is probably no more than about 3 $\mu g/m^3$ based on the one report for a nearby town, or 60 µg/day. In addition, 1,1,2,2-tetrachloroethane has occasionally been detected in the vicinity of the organic chemical production facilities of Baton Rouge, LA, and Houston, TX, generally at levels less than 0.1 $\mu g/m^3$. If 24-hour exposure were occurring at this level, the resultant intake would be about 2 µg/day. However, it should be pointed out that the data are extremely limited, and the frequency of detection is quite low.

By way of comparison, the OSHA exposure standard for this compound is 35 $\mu g/m^3$ (time-weighted average), while the NIOSH recommended exposure standard is 7 $\mu g/m^3$ (time-weighted average).

While the focus of this assessment is not primarily on occupational exposure, at one time inhalation or dermal adsorption in the workplace may have constituted the most significant route of human exposure in the U.S. In 1978, NIOSH estimated that 11,000 people were exposed to 1,1,2,2-tetrachloroethane in the workplace (NIOSH 1978). However, this report was based on worker exposure surveys conducted between 1972 and 1974, while 1,1,2,2-tetrachloroethane was still being produced in significant quantities for uses in several industries. More recently, deliberate U.S. production has ceased, although the chemical is still produced inadvertently in manufacturing vinyl chloride monomer and 1,1,1-trichloroethane (Chapter 3.0). No information is available on estimated manufacture of these other solvents but given the recent concern over exposures to vinyl chloride monomer (also an intermediate in 1,1,1-trichloroethane manufacture) and resulting protective measures, the current potential for occupational exposure to 1,1,2,2-tetrachloroethane should be very low.

REFERENCES

Brem, H.; Stein, A.B.; Rosenkranz, H.S. The mutagenicity and DNA-modifying effect of haloalkanes. Cancer Res. 34:2576-2579; 1974. (As cited by IARC 1979)

Browning, E. Toxicity of Industrial Organic Solvent, London. Her Majesty's Stationery Office, pp. 154-163; 1953. (As cited by IARC 1979).

Deguchi, T. A fundamental study of the threshold limit values for solvent mixtures in the air -- Effects of single and mixed chlorinated hydrocarbons upon the level of serum transaminases in rats. Osaka City Med. Jour. 21:187; 1972. (As cited by U.S. EPA 1979)

Hamilton, A.; Hardy, H.L. Industrial Toxicology, 3rd ed., Acton, MA, Publishing Sciences Group Inc., pp. 277-291; 1974. (As cited by IARC 1979)

Horiguchi, K.; et al. Studies on the industrial tetrachloroethane poisoning (2). Osaka City Med. Jour. 8:29; 1962 (As cited by U.S. EPA 1979)

IARC monographs on the Evaluation of the Carcinogenic Risk of Chemicals to Humans: some halogenated hydrocarbons. 20:477-489; 1979.

Kim, N.K.; Stone, D.W. Organic chemicals and drinking water: characterization of organic chemical water quality problems in New York State. Albany, N.Y.: New York State Department of Health. No date.

Morgan, A.; et al. The excretion in breath of some aliphatic halogenated hydrocarbons following administration by inhalation. Ann. Occup. Hyg. 13:219; 1970. (As cited by U.S. EPA 1979)

Morgan, A.; et al. Absorption of halogenated hydrocarbons and their excretion in breath using chlorine-38 tracer techniques. Ann. Occup. Hyg. 15:273; 1972. (As cited by U.S. EPA 1979)

National Cancer Institute. Bioassay of 1,1,2,2-tetrachloroethane for possible carcinogenicity. DHECO Publication No. (NIOH) 78-727, Washington DC, U.S. Department of Health Education and Welfare; 1978.

National Institute of Occupational Safety and Health (NIOSH). Chloroethanes, review of toxicity. Current Intelligence Bulletin No. 27, Publication 78-181. Washington, DC: U.S. Department of Health, Education and Welfare; 1978.

Navrotskig, V.K.; et al. Comparative assessment of the toxicity of a number of industrial poisons when inhaled in low concentrations for prolonged periods. Trudy S'ezda Gigenistov, Ukranixoi 8:229; 1971. (As cited by U.S. EPA 1979)

Parker, J.C.; Casey, G.E.; Bahlman, L.J.; Leidel, N.A.; Rose, D.; Stein, H.P.; Thomas, A.W.; Lane, J.M. Chloroethanes: a review of toxicity. Am. Ind. Hyg. Assoc. J. 40(3):A-46-A-60; 1979.

Registry of Toxic Effects of Chemical Substances (RTECS). Lewis, R.J.; Talken, R.L., eds. Cincinnati, OH: U.S. Department of Health Education and Welfare. Public Health Service. Center for Disease Control. National Institute for Occupational Safety and Health: 1978.

Schmidt, R. The embryotoxic and teratogenic effect of tetrachloroethane -- experimental investigations (Germ.). Biol. Rundschau. 14:220-223; 1976. (As cited by IARC 1979)

U.S. Environmental Protection Agency (U.S. EPA) National Organics Monitoring Survey (NOMS). Draft. Washington, DC: Office of Water Supply, U.S. Environmental Protection Agency; 1978.

U.S. Environmental Protection Agency (U.S. EPA). Ambient water quality criteria. Criterion document -- chlorinated ethanes. Washington, DC: Criteria and Standards Division, Office of Water Planning and Standards. 297-920; 1979, 111 p.

U.S. Environmental Protection Agency (U.S. EPA). Ambient water quality criteria for chlorinated ethanes. Report EPA-440/5-5-80-029. Washington, DC: Criteria and Standards Division, Office of Water Regulations and Standards, 1980.

6.0 EFFECTS AND EXPOSURE--AQUATIC BIOTA

6.1 EFFECTS ON AQUATIC BIOTA

The laboratory toxicity data for 1,1,2,2-tetrachloroethane are very limited, the chronic data even more so than the acute. Toxicity and bioaccumulation generally increase directly with increasing chlorination of the chlorinated ethanes, hexachloroethane being the most toxic (U.S. EPA 1980). Available acute data for 1,1,2,2-tetrachloroethane are presented in Table 6-1.

In an embryo-larval test, a chronic value* of 2,400 µg/l was derived for the fathead minnow (U.S. EPA 1978). This represents the lowest level at which effects of 1,1,2,2-tetrachloroethane have been observed in the laboratory.

6.2 EXPOSURE OF AQUATIC BIOTA

STORET monitoring data for ambient and effluent waters indicate that a majority of values were below 10 µg/l. In ambient waters there were two observations in the range 100.1-1000 µg/l (see Table 4-1) which is still below the apparent threshold of toxic effects levels to aquatic biota. Two observations over 1000 µg/l were also reported, but these appeared to represent temporary situations. There appears to be no overlap between exposure levels in water, and concentrations that are acutely or chronically toxic to aquatic organisms. However, data on the effects of 1,1,2,2-tetrachloroethane on aquatic organisms are extremely limited.

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*Chronic values are calcualted from embryo-larval tests showing effects on early life stages. They are meant to represent a no-effect-level for chronic exposure.

TABLE 6-1. TOXICITY OF 1,1,2,2-TETRACHLOROETHANE FOR FRESHWATER AND SALTWATER BIOTA

Species	Test	LC_{50}/EC_{50} (µg/l)	Reference
Freshwater:			
Cladoceran (*Daphnia magna*)	48 hour (static)	9,320	U.S. EPA (1978)
Fathead minnow (*Pimephales promelas*)	96 hour (flow-through)	20,300	U.S. EPA (1980)
Bluegill (*Lepomis macrochirus*)	96 hour (static)	21,300	U.S. EPA (1980)
Alga (*Selenastrum capricornutum*)	chlorophyll *a* 96 hour	136,000	U.S. EPA (1978)
	cell numbers 96 hour	146,000	U.S. EPA (1978)
Saltwater:			
Mysid shrimp (*Mysidopsis bahia*)	96 hour (static)	9,020	U.S. EPA (1978)
Sheepshead minnow (*Cyprinodon variegatus*)	96 hour (static)	12,300	U.S. EPA (1978)
Alga (*Skeletonema costatum*)	chlorophyll *a* 96 hour	6,440	U.S. EPA (1978)
	cell 96 hour	6,230	U.S. EPA (1978)

REFERENCES

U.S. Environmental Protection Agency (U.S. EPA). In-depth studies on health and environmental impacts of selected water pollutants. Contract No. 68-01-46-46, U.S. Environmental Protection Agency; 1978. (As cited by U.S. EPA 1980.)

U.S. Environmental Protection Agency (U.S. EPA). Ambient water quality criteria for chlorinated ethanes. Report No. EPA-440/5-80-029. Washington, DC: Office of Water Regulations and Standards, U.S Environmental Protection Agency; 1980.

7.0 RISK CONSIDERATIONS

7.1 RISK CONSIDERATIONS FOR HUMANS

The compound 1,1,2,2-tetrachloroethane has been shown to be carcinogenic in mice, mutagenic in two bacteria and a yeast, and teratogenic in mice (see Table 7-1).

Based on the evidence of animal carcinogenicity, EPA's Carcinogen Assessment Group designated 1,1,2,2-tetrachloroethane as a suspected human carcinogen. Subsequently, EPA's Office of Water Regulations and Standards specified the ambient freshwater quality criterion for maximum protection of human health as zero µg/l. The levels in water calculated to result in incremental lifetime cancer risk of 10^{-5}, 10^{-6}, and 10^{-7}, through ingestion of both water and contaminated aquatic organisms, are 1.7 µg/l, 0.17 µg/l, and 0.017 µg/l, respectively (U.S. EPA 1980).

While any evidence of human exposure is of concern, there are very few data indicating significant exposure at the present time. Table 7-2 summarizes the available data on human exposure for 1,1,2,2-tetrachloroethane. Occasionally, this compound has been detected in groundwater levels less than 10 µg/l. In addition, there are a few reports of levels in ambient waters exceeding 1.7 µg/l; the sources in these instances of high ambient concentrations have been identified in virtually all cases and do not appear to represent consistent releases. It is of note, however, that the detection limits in many cases where this chemical was analyzed for but not detected were greater than 1.7 µg/l. Consequently, these data suggest that the consumption of surface water could be a significant route of exposure for the small subpopulation ingesting untreated surface waters. However, the lack of detection of this chemical in NOMS, at detection limits probably on the order of 0.01 µg/l, suggests either that this chemical is being removed in treatment, or is not present at higher levels in the drinking water supplies sampled.

Although 1,1,2,2-tetrachloroethane has not been detected in drinking water *per se*, groundwater contamination may represent the greatest potential for exposure to 1,1,2,2-tetrachloroethane, as evidenced by the one example found (see Table 7-2). The volume of production of this chemical in 1977 was about 22,000 kkg, primarily used captively as an intermediate. Production ceased as of March 1978, and only about 60 kkg were imported in 1980, primarily for solvent uses (Chapter 3.0). The extent of solvent use in the past is unknown, but may have been somewhat greater than the present use. In addition, 1,1,2,2-tetrachloroethane is present in vinyl chloride monomer tars and heavy ends, as well as in solid waste from 1,1,1-trichloroethane manufacture. To the extent that these wastes are or were disposed of in landfills, they represent a source of potential groundwater contamination.

TABLE 7-1. EFFECTS OF 1,1,2,2-TETRACHLOROETHANE ON LABORATORY ANIMALS AND HUMANS

Effect	Species	Dose	Response
Carcinogenicity	female B6C3F1 mice	203 mg/kg/day-78 weeks	91% incidence (hepato-cellular carcinoma)
		101 "	63%
		0 "	0
	male B6C3F1 mice	203 "	90%
		101 "	26%
		0 "	6%
Mutagenicity	Salmonella typhimurium strains TA 1530 and 1535		mutations of base substitution type
	DNA-polymerase-deficient Escherichia coli		positive
	Saccharomyces cerevisiae		positive
Teratogenicity	DBA and AB-Jena strain mice	300-400 mg/kg/day during organogenesis	exencephaly, cleft palate, anophthalmia
Liver and kidney pathology	rats	13 mg/m^3(air)-4 hrs/day for up to 265 days	liver pathology
	rabbits	100 mg/m^3 4 hrs/day for 11 months	lowest effect level for liver and kidney degeneration
Lethal doses	humans	50 mg/kg	lowest reported lethal dose via ingestion
	humans	1000 mg/m^3/30 min.	lowest reported lethal dose via inhalation.

Source: See Chapter 5.0.

TABLE 7-2. SUMMARY OF AVAILABLE INFORMATION ON HUMAN EXPOSURE TO 1,1,2,2-TETRACHLOROETHANE

Exposure Route	Survey or Location	Levels Reported	Estimated Resulting Exposure
Ingestion - Drinking Water (assumes 2ℓ/day consumption)	NOMS	detected in an unspecified number of cases, but not quantified	
	STORET - ambient water	40 observations unremarked data, 38% ≤ 1µg/1, 66% ≤ than 10 µg/1, 91% ≤ 100 µg/1.	2-200 µg/day
		400 observations remarked[a] data 21% ≤ 1 µg/1, 92% ≤ 10 µg/1.	
	STORET - well water	not detected	
	New York State - well water	39 wells - detected in lat unquantified level	
	New Jersey - ground water	detected in 2.1% of 1118 samples, maximum of 2.1 µg/1.	
	N. Muskegon, MI-OH/ Story Chemical site	ground water contamination <5-1590 µg/1[b]	maximum of 3200 µg/day
Ingestion - Food	STORET - fish tissue	not detected	
Inhalation (assumes 20 m^3/day respiratory flow)	Kin-buc Disposal site, Edison, NJ	3 µg/m^3	60 µg/day
	Baton Rouge, LA	<0.1 µg/m^3	<2 µg/day
	Houston, TX (production facilities for other organic chemicals)		

[a]Remarked data indicates that levels are less than the detection limit or the value shown.
[b]Attributed to disposal of solvent wastes including 1,1,2,2-tetrachloroethane in previous years.

Source: See Chapter 5.0.

Food does not appear to represent a significant source of exposure of humans to 1,1,2,2-tetrachloroethane due to the relatively low bioaccumulation potential of the compound. However, data available for assessing this exposure route are extremely limited.

Inhalation appears to be a possibly significant exposure route in some locations. Evidence of potential exposure exists only for one waste disposal site, but comparable exposures may exist in others. In addition, the compound was occasionally detected in the vicinity of chlorinated organic production facilities. Although the levels reported were high, the frequency of detection was low (see Chapter 4.0).

In conclusion, while there may be some potential for contamination of groundwaters with 1,1,2,2-tetrachloroethane due to past waste disposal practices and, to a lesser extent, continued landfilling of wastes from vinyl chloride monomer and 1,1,1-trichloroethane manufacture, relatively few instances of actual groundwater contamination have been reported, along with even fewer reports of drinking water contamination. Thus, the subpopulations exposed to this compound in water cannot be reliably quantified from existing information but are likely to be very small. In addition, there are a few locations in the U.S. where atmospheric levels of 1,1,2,2-tetrachloroethane may be detected, suggesting limited exposure via inhalation.

The lowest level at which effects on aquatic organisms have been observed in the laboratory is 2400 µg/l for chronic effects. The limited monitoring data suggest that ambient levels are generally below the detection limit of 10 µg/l. Two observations of greater than 1000 µg/l were reported, however; these appeared to represent temporary situations. Thus, based on the very limited data available, 1,1,2,2-tetrachloroethane does not appear to represent a material risk to aquatic biota.

7.2 RISK CONSIDERATIONS FOR AQUATIC BIOTA

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REFERENCE

U.S. Environmental Protection Agency (U.S. EPA). Ambient water quality criteria for chlorinated ethanes. Report No. EPA-440/5-80-029. Washington, DC: Office of Water Regulations and Standards, U.S. Environmental Protection Agency; 1980.